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Design and Manufacturing of Hydraulic Spring Stiffness Testing Machine

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Abstract: *In Industries they purchase the springs for their hydraulic valves but they are facing the problem of checking the spring stiffness. After understanding the Industries problems for spring testing we designed and developed hydraulic spring stiffness testing machine. Only considering the two parameters load and deflection) we can calculate spring stiffness. The machine is based on the requirement of the company which manufacture different valve. So according to the requirement of company, hydraulic spring testing machine is developed.*

Keywords: *spring stiffness,load and deflection,spring testing machine.*

1. INTRODUCTION

An engineer is always focused towards challenges of bringing ideas and concepts to life. Therefore, sophisticated machines and modern techniques have to be constantly developed and implemented for economical manufacturing of products. At the same time, quality and accuracy factor is considered. A spring is defined as an elastic machine element, which deflect under the action off the load and returns to its original shape when the load is removed. Stiffness and spring index are the main parameters of spring design. Spring stiffness is the force per unit deflection[1]. These parameters are considered for defining the spring. In designing and developing the spring testing machine, these parameter is considered. Hydraulic principle considered while designing and developing the stiffness machine.

2. HYDRAULIC SPRING STIFFNESS TESTING MACHINE

2.1. Problem Definition

Many companies manufacture valves and they required the springs for installing in their products (hydraulic valves). Depending upon the valve size there is variations in sizes and shapes of springs, hence company are facing problem of checking stiffness of spring. Understanding the Industry problems, we have designed and developed a hydraulic spring stiffness testing machine.

2.2. Objectives of Study

The objectives are as follows:-

- To reduce testing cost.
- To reduce investment cost on machine.
- To increase profit of company.
- To save time.

2.3. Hydraulic Spring Stiffness Testing Machine Constriction

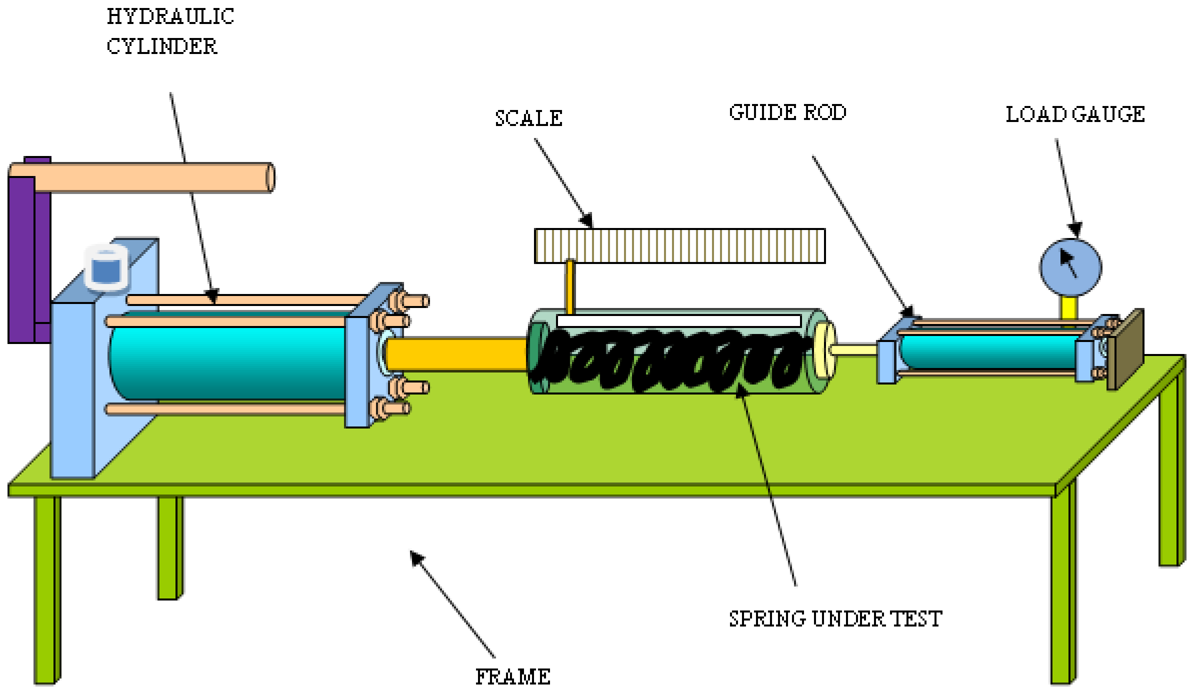

Fig1. *Conceptual view of hydraulic spring stiffness testing machine*

Fig. 1 shows the conceptual view of hydraulic stiffness testing machine, following are the main element of the this machine

2.3.1. Large Cylinder

Large cylinder: Single acting cylinder as shown in fig.2 having pressure capacity 15kg/cm^{2}and force can be apply about 550 kg. Load is applied at one end and due to which spring gets deflected. There are various method of applying load. Here we are using by hydraulically operated piston and cylinder.

Fig2. *Large Single acting cylinder*

2.3.2. Small cylinder

As shown in fig.3 single acting cylinder pressure capacity 10 kg/cm^{2}and force applied about 100 kg used to combine the action of deflection and load measured to give output.The Bourdon tube is a metal tube of elliptical shape. The inside of the tube is exposed to the pressure to be measured. The Bourdon tube is held fixed at one end connected to the pressure source. A pointer is mounted on the shaft, as indicated in the figure. The needle moves over a circular scale that indicates the pressure. The position of the needle is determined by a pressure act on it.

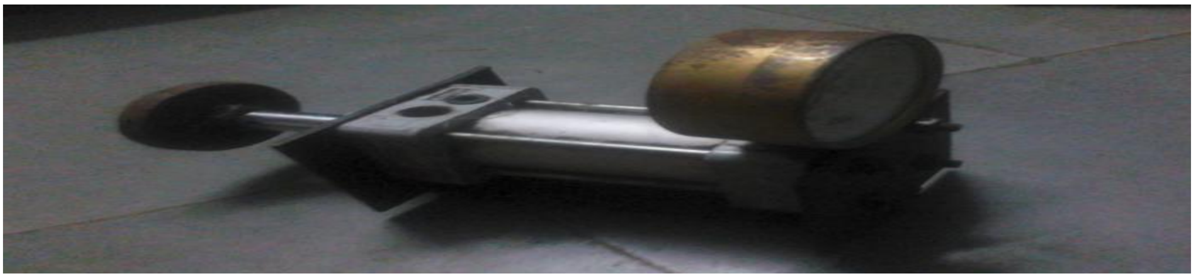

Fig3. *Small cylinder with pressure gauge*

2.4. Working Principle of Spring Stiffness Testing Machine

There are two cylinder of different diameter, which is interconnected by same liquid. The pressure is transmitted from larger cylinder to smaller cylinder by application of a lever. The smaller cylinder is having plunger and larger cylinder is having ram (piston and piston rod). Larger cylinder is having a lever mounted over it. When force is applied by lever it gets multiplied to many times and that multiplied force acts on the plunger. Due to this force the plunger compresses the liquid. The liquid will be pressurized as it is confined between plunger and piston. This pressure in liquid is transmitted by liquid to piston. As the piston is having larger area then plunger, the force delivered by piston and piston rod is much larger then force acting on the plunger. The piston rod moves outwards and presses the hardened ball through dent pipe supported between the two pillars and dent is removed to required size. When the release knob is opened the pressurized liquid gets escaped into the reservoir and due to the spring action of retracting spring the piston is brought backward.

3. Design Manufacturing and Assembly of Hydraulic Spring Stiffness Testing Machine

In this designing section design of various parts such as large cylinder, small cylinder of hydraulically operated spring stiffness machine is done. Assuming various parameters we can obtain diameters, thickness and applied force of cylinder. They are as follows;

- Design of Large Cylinder
- Design of piston rod.
- Design of small cylinder

The manufacturing consists of base which is built using frame construction on which components are mounted. As per design and dimensions of the component the base dimensions are finalized which consist of a frame. Aframe construction with dimensions as shown in fig4.Frame consists of a centre support on which the component is assembled. The centre construction consist of a slot in which small cylinder can be moved to and fro according to the requirement. The slot consistsof 2 cm spacing.

The bigger is mounted on one side, which is fixed rigidly as the force applied by bigger cylinder and other side small cylinder is fixed by bolt and nut arrangement.

The guide consists of hollow pipe construction which is placed at centre. The pipe can open half and close after placing the spring as it is used for safety purpose. The guide constructed in such a way that the nut can be loosened and tightened according to which the height of the guide can be adjusted and it can easily remove when it is not required.

The cylinder has a front attachment of 70 mm circular section rigid welded at the cylinder end of bigger and smaller cylinder. This attachment is used to force the spring from bigger cylinder and on small cylinder it is used to measure force applied on spring. The smaller cylinder is mounted with the bourden gauge which shows the force applied by the bigger cylinder on spring specimen.

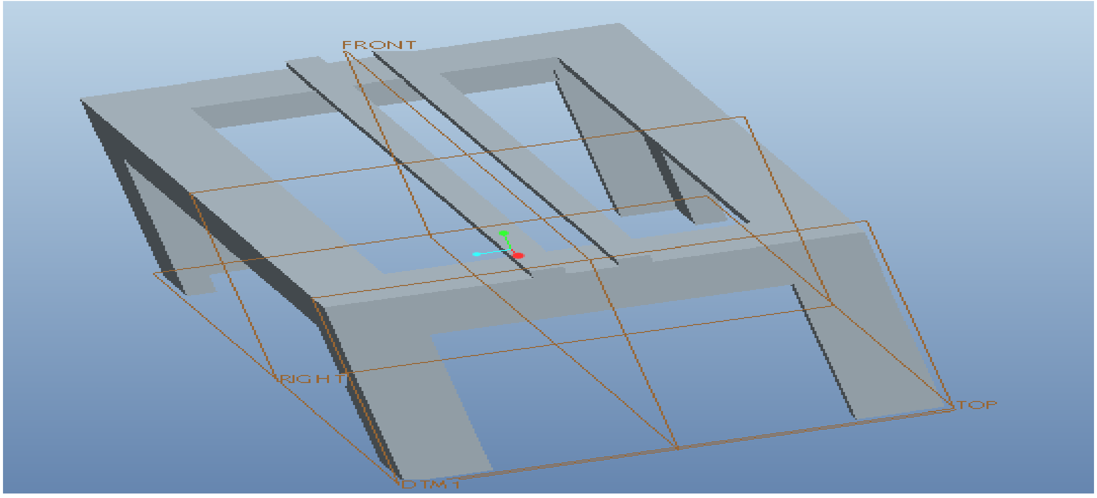

Fig4. *3D Drawing of manufacturing of base frame*

The hydraulic spring testing machine assembled in following manner:

- Take the plunger pump housing and the side having maximum cross section area and four holes, mark its center.
- Now take the pressure cylinder and place it over the plunger pump housing and weld it circumferentially such that two holes should be in and two holes out of its coverage.
- Similarly place and weld the reservoir cylinder on the plunger pump housing and pressure cylinder.
- Mark the center of end block on one of its side, which is not tapped, and draw a circle.
- Place the former assembly on this circle and weld the pressure cylinder circumferentially on the end block.
- On the other end of plunger pump housing, fit the lever with nut and bolt.
- Fit the piston, cup seal and back up place to the piston rod with the help of L key nut and insert this assembly into the pressure cylinder through the end block.
- Then insert the retracting spring over the piston rod and enclose this assembly into the pressure cylinder by tightening the piston rod guide to the end block.
- Fit the lower and upper wings to the end block by means of boots.
- The assembly thus formed is placed on the stand.
- After this insert all the valves into plunger pump housing along with balls and washers.
- Remove the refill cap from the reservoir cylinder and fill the reservoir by hydraulic oil and tighten the cap.
- Thus, the assembly of hydraulic spring testing machine is ready.

4. Testing and Results

Various sizes of springs are tested on hydraulic spring stiffness machine and we got the following results which we compare them with the digital machine which is available in Vijay spring manufacturer.

Steps to be followed to find out stiffness of spring, that is as follows;

- On this machine compression helical spring of different cross sections, stiffness can be checked with suitable adapter. Design of machine is very simple and table mounting type for easy operation. Assembly drawing is as shown in fig. To adjust the different length spring moving small cylinder is provided to set the length and it can be locked by lock nut at suitable length.
- Take the spring and measure its free length. Adjust the gap between moving adapter and adjustable small cylinder equals to free length of spring by moving small cylinder. Keep the spring on center position of moving table and again adjust correctly. Then lock the moving small cylinder by tightening the lock nut.
- Next set the pointer on the scale to 'ZERO' mark. Operate the hand lever of hand operated pump slowly. Ram descends and pr. Gauge starts to give reading.
- Note the deflection by reading the pointer position. Then note the pressure again continue the same procedure to get still 4-5 readings.

Result for various diameters which is tested on hydraulic spring testing machine is given below followed by comparison with digital machine available in Vijay spring manufacturer.

Table1. *Result for 5mm wire diameter on digital standard machine*

Sr.no.	Deflection (mm)	Pressure kg/cm^2	N/mm^2	Area	Force	Stiffness K	Average
1	10	0.5	0.049	1256	61.54	6.15	
2	20	1	0.0981	1256	123.21	6.16	6.41
3	30	1.6	0.1569	1256	197.06	6.56	
4	40	2.2	0.2158	1256	271.04	6.77	

Table2. *Result for 5mm wire diameter on digital standard machine*

Sr.no.	Deflection	Load(kg)	Stiffness	Average
1	10	6.5	6.31	
2	20	13.1	6.42	6.43
3	30	19.85	6.49	
4	40	26.56	6.52	

Table3. *Result for 7 mmwire diameter on hydraulic spring testing machine:*

Sr.no.	Deflection (mm)	Pressure kg/cm^2	N/mm^2	Area	Force	Stiffness K	Average
1	10	1.6	0.1569	1256	197	19.7	
2	20	2.8	0.2746	1256	344.8	17.24	17.38
3	30	4	0.3921	1256	492.3	16.41	
4	40	5.2	0.5143	1256	640.5	16.04	

Table4. *Result of 7 mm wire diameter on digital standard machine*

Sr.no.	Deflection	Load(kg)	Stiffness	Average
1	10	16.55	16.22	
2	20	33.42	16.39	16.4
3	30	50.42	16.45	
4	40	67.3	16.52	

From these results we can see that there is little difference in readings of hydraulic testing machine and digital machine. The percentage error is near about 2.The error in the reading may be caused due to reasons such as systematic, random, and gross error.

5. ADVANTAGE, DISADVANTAGE AND APPLICATIONS OF HYDRAULIC SPRING STIFFNESS MACHINE

5.1. Advantages

- Spring of different diameters can be checked.
- Spring can be check without damaging the spring.
- The testing is carried out in very less time, so production rate is very high.
- One man effort is enough to check the spring.
- Semi-skilled and unskilled labour can operate this machine easily.
- The system is self-lubricating.
- The system is noiseless.
- It is portable and could be carried anywhere.

5.2. Disadvantages

- Spring wire diameter cannot be checked below 40mm and above 70mm.
- As system is hydraulic, leakage may occur and hence refilling of coil is necessary.

5.3. Application

- The machine is used for measuring spring stiffness for different spiral and helical springs in the range of 40mm to 60mm.
- Can be used in garages where frequent inspection of the suspension of various automobiles is carried out.
- With the help of this machine it is possible to analyze when to replace the suspension by comparing the stiffness of the testing suspension with that of the standard stiffness.

6. CONCLUSION

The spring stiffness testing machine is designed and developed by using hydraulic principle. It consist mainly large cylinder, small cylinder, deflection scale and bourdon tube gauge. On the spring stiffness testing machine we can test spring having diameter range of 40 mm to 70 mm. The results have been verified with the calibrated digital stiffness testing machine. This machine reduces the checking time and cost when compared with conventional machine.

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